REMARKS

The applicants thank the Examiner for the thorough examination of the application. No new matter is believed to be added to the application by this amendment.

Status Of The Claims

Claims 1, 3-5, 8, 11, 13-15, 18, and 21-23 are pending in this application. Claims 9 and 19 are cancelled by this amendment. Claims 1 and 13 have been amended to incorporate the subject matter of claims 9 and 19, respectively. Claims 4, 5, 14 and 15 have been amended to improve their language. The amendments to claims 1 and 13 also find support at page 9, line 17 to page 10, line 5, and at page 11, lines 20-25 of the specification. Claims 22 and 23 recited subject matter cancelled from claims 1 and 13, respectively.

Claims Analysis (page 2 of the Office Action)

The Examiner analyzes claims 1, 5, 13 and 15 to assert that these claims recite intended use limitations that have no patentable weight. However, these claims have been amended to positively recite limitations that are not conditional intentions to use. For example, claims 1 and 13 recite that "the fuel cell is accommodated to an apparatus." Also, claims 5 and 15 recite that

"said fuel cell is attached to a portable device as a power source." As a result, these limitations clearly have patentable weight.

Claim Objections (page 2 of the Office Action)

The Examiner objects to the wording of claim 1. The Examiner's comments have been considered. Claim 1 has been amended to reflect the Examiner's suggestion to recite "at least one of the fuel electrode [[and]] or the air electrode."

Rejections Under 35 U.S.C. §112, First Paragraph (page 3 of the Office Action)

Claims 1, 3-5, 8, 9, 11, 13-15, 18, 19 and 21 are rejected under 35 U.S.C. §112, first paragraph as failing to comply with the written description requirement. Applicants traverse.

In the Office Action, the Examiner asserts that there is insufficient support for the limitation to claims 1 and 13 (now removed from claims 1 and 13 and present in claims 22 and 23) reciting that the fuel cell: "operates at a temperature to cause output of electric power at 100°C or less."

However, the originally filed specification of the U.S. application at page 16, lines 6-10 states: "The fuel cell of the present invention is easy to miniaturize, has high output power density, and operates at a low temperature

as low as 100°C or less, so that it is expected to have a long term durability and is easy to handle." (Emphasis added).

As a result, this limitation now in claims 22 and 23 finds support at least as of the filing date of the U.S. application. Additionally, this rejection now applies only to claims 22 and 23, and the rest of the claimed invention is free from this rejection.

This rejection is overcome and withdrawal thereof is respectfully requested.

Rejection Under 35 U.S.C. §112, Second Paragraph (pages 3-4 of the Office Action)

Claims 4 and 14 are rejected under 35 U.S.C. §112, second paragraph as being indefinite. Applicants traverse.

In the Office Action, the Examiner asserts imperfections in antecedent basis in claims 4 and 14 pertaining to the limitations "fuel" and "the surface." The Examiner's comments have been considered. Claims 4 and 14 have been amended in a non-narrowing way to be clear, definite and have full antecedent basis.

This rejection is overcome and withdrawal thereof is respectfully requested.

Rejection Under 35 U.S.C. §102(b) Over Muthuswamy (pages 4-5 and 7 of the Office Action)

Claims 13-15, 18 and 21 are rejected under 35 U.S.C. §102(b) as being anticipated by Muthuswamy (U.S. Patent 6,060,188). Applicants traverse.

Independent claim 13 has been amended to incorporate the dimensional limitations of claim 19, now cancelled. Claim 19 was free of this rejection over Muthuswamy, and independent claim 13 is hence now instantly patentable over Muthuswamy. Claims depending upon claim 13 are patentable for at least the above reasons.

This rejection is overcome and withdrawal thereof is respectfully requested.

Rejections Under 35 U.S.C. §103(a) Over Bass And Muthuswamy (pages 5-7 of the Office Action)

Claims 1, 3-5, 8, 9, 11, 13-15, 18, 19 and 21 are rejected under 35 U.S.C. §103(a) as being obvious over the combination of Bass (U.S. Patent 6,001,500) with Muthuswamy. Applicants respectfully traverse.

The Present Invention And Its Advantages

The present invention pertains to a novel flexible fuel cell whose physical (or mechanical) flexibility renders it suitable for utilization in compact portable devices such as mobile phones, video cameras, notebook-type personal computers, i-pods, etc. The physical flexibility of the inventive fuel cell is

achieved, in part, by the combination of a tubular polymer electrode with a carbon particle material or a catalyst. Another advantage of the invention arises from the fuel cell's compact size. The inventive fuel cell can have an inner cavity with a diameter of 0.2 to 10 mm, an outer diameter of 0.5 mm to 12 mm and a length of 20 to 1000 mm (see claims 1 and 13).

The present invention finds a typical embodiment in instant claim 1:

> **1.** (Currently Amended) A fuel cell, consisting essentially of:
> (i) a tubular polymer electrolyte membrane, with a fuel electrode on an inner side of the membrane, and with an air electrode on an outer side of the membrane;
> (ii) at least one of the fuel electrode or the air electrode is composed of a carbon particle material having a surface on which catalyst fine-particulates are dispersed and loaded; and
> (iii) the remaining electrode being composed of a catalyst,
> wherein the fuel cell has a hollow or cavity having a diameter in a range of 0.2 to 10 mm, an outer diameter of the fuel cell having a range of 0.5 to 12 mm, and a length of the fuel cell having a length of from 20 to 1000 mm,
> wherein the polymer electrolyte membrane prevents a fuel on the inner side of the membrane from leaking,
> wherein methanol is introduced as the fuel into the hollow or cavity of the fuel cell to obtain an output power,
> wherein the combination of the carbon particle material and the tubular polymer electrolyte membrane brings about a flexibility of the fuel cell, and
> wherein the flexible fuel cell is accommodated to an apparatus.

In the claimed invention, methanol is used as fuel. In contrast, conventional hydrogen fuel presents hazards that fail to satisfy the requirements fulfilled by the invention. That is, hydrogen is not suitable for use in portable devices because the hydrogen technology generally requires a

high gas pressure during operation. Also, a bulky reformer is required in the vicinity of the hydrogen cell.

In contrast, the invention is directed at a small and flexible fuel cell that is suitable for portable devices. Portable devices have numerous electric parts such as a circuit board, wiring, a power source, etc. These parts are integrated and packed into a restricted space to form the compact body of the portable device. Particularly, a power source is one of the essential parts of every device. Conventional power sources are bulky and large. In contrast, the present invention combines miniaturization with flexibility. The inventive flexible fuel cell can bend repeatedly to respond or conform to changes. As a result, the invention can accommodate the limited space found in portable electronic devices.

Distinctions Of The Invention Over Bass and Muthuswamy

Distinctions of the invention over Bass and Muthuswamy have been placed before the Examiner. For brevity, these distinctions are not repeated at length here.

Bass pertains to a cylindrical membrane fuel cell that uses hydrogen as fuel (claim 1). Bass fails to disclose or suggest a low-temperature, flexible fuel cell technology that uses methanol, much less a fuel cell structure that provides safety and easy handling. Bass additionally fails to disclose a fuel cell having the claimed dimensions of the present invention.

In contrast, the present invention achieves a novel and significant miniaturization of tubular fuel cell technology for practical use. The dimensions of the inventive fuel cell include an inner diameter in a range of from 0.2 to 10 mm, an outer diameter in a range of from 0.5 to 12 mm and a length in a range of from 20 to 500 mm. Thus, the size of the inventive fuel cell can be miniaturized to accommodate every desired output of electric power for modern electronic devices.

In contrast, Bass is size restricted. Bass fails to give any teaching or suggestion of how to realize a fuel cell usable in a small electronic device. Table 1 in Bass specifically shows fuel cell samples with an inner diameter of 1.8 mm (inner radius of 0.09 cm) and an outer diameter of 36 mm (outer radius of 1.8 cm) at smallest. This outer diameter is of more than triple the diameter of the fuel cell claimed in the present invention. Further, this hydrogen fuel cell of Bass reveals a remarkably thick construction, ca., 34 mm (OD-ID=36-1.8).

In comparison, the physically flexible fuel cell of the present invention does not require such thickness, and can operate, e.g., even with the thickness of 0.2 mm (Example 1).

In this regard, Bass does disclose a cylindrical membrane having an inner diameter of 2.16 mm with 0.09 mm thickness. This is, however, a general explanation of a commercially available membrane. This fuel cell can never be miniaturized because of the membrane's mechanical and overheating problems, which are described below.

Bass fails to employ a solid (firm) cylindrical conductive matrix that is flexible and easy to bend. In comparison, the present invention adopts a novel laminar construction having carbon particles with catalyst loaded and/or catalyst being laminated on the surface of the PEM (Polymer Electrolyte Membrane).

As a result, formation of a solid matrix is avoided, and the inventive fuel cell synergistically attains an unexpected physical flexibility.

In contrast, Bass' fuel cell necessitates the solid (firm) cylindrical porous conductive matrix (claim 1 or 24) for mechanical support. This is because overheating of Bass' fuel cell requires a lot of cooling airflow, and a solid material is essential to sustain its high pressure (Bass at column 9, lines 54 to 67). Further, Bass describes that "carbon rod, other non-laminar, or the substantially solid structure is advantageous (Bass at column 6, lines 46 to 49)." Without the solid structure, the fuel cell of Bass would never operate. Thus, the principle of operation of Bass must be changed in order to modify the reference.

If a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984). If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render

the claims *prima facie* obvious. *In re Ratti*, 270 F.2d 810, 123 USPQ 349 (CCPA 1959).

Bass also teaches away from the invention.

That is, the necessity of the "solid cylindrical matrix" is further clearly demonstrated in Examples in Bass. Specifically, prototype 5 is a coreless fuel cell sample (Bass at column 10, lines 3 to 5) that has insufficient firmness, shows hydrogen leakage and fails to supply output power. They conclude, pertaining to this result, that their fuel cell requires more thickness (descriptions and Tables on col. 16). That is, Bass at column 17, lines 1-11 discusses using larger rods and more solution layers. As a result, Bass teaches away from the subject matter of the present invention.

A *prima facie* case of obviousness may also be rebutted by showing that the art, in any material respect, teaches away from the claimed invention. *In re Geisler*, 116 F.3d 1465, 1471, 43 USPQ2d 1362, 1366 (Fed. Cir. 1997). It is improper to combine references where the references teach away from their combination. *In re Grasselli*, 713 F.2d 731, 743, 218 USPQ 769, 779 (Fed. Cir. 1983).

At page 6 of the Office Action, the Examiner admits that Bass fails to utilize methanol for fuel. The Examiner then turns to Muthuswamy.

Muthuswamy pertains to a high-pressure fuel cell the employs a "stiff and rigid central core" (see Muthuswamy at column 4, line 11). This rigidity is required because Muthuswamy aims at a fuel cell that can operate at high

pressures (see Muthuswamy at column 5, lines 22-23). As a result, it is clear that the fuel cell of Muthuswamy has a solid construction.

As a result, Muthuswamy's fuel cell has a rigid structure that cannot be accommodated to a small device. In contrast, the inventive fuel cell is flexible.

At page 7 of the Office Action, the Examiner argues: "Applicant argues the fuel cell of Muthuswamy is not flexible because the fuel cell has a rigid central core. However, rigid does not equate to non-flexible. Furthermore, Muthuswamy teaches the fuel cell has a variable cross section (flexible) for creating a fuel cell that can fit easily into a contoured package (3:8-12)."

However, a reading of the passage of Muthuswamy at column 3, lines 8-24 leads to the opposite conclusion:

> The porous central core could also have a dynamically varying cross-sectional shape, resulting in a fuel cell of variable cross section. This may be desired for creating fuel cells that fit easily into a contoured package, for example a battery housing for a two-way radio. One preferred material for the porous central core is a reticulated ***vitreous aluminum matrix*** known as DUOCEL®, made by ERG of Oakland, Calif. DUOCEL® is a rigid foam material made from 6101-O aluminum alloy, and has densities from 6-8%, and is available in 10, 20 and 40 pores per inch (PPI). Other ***reticulated materials***, such as carbon and other metals, are also available. ***One primary advantage of this material is that it is very rigid***, thus providing a solid base to fabricate the fuel cell around. The porous central core also serves as the distributing medium for the oxidant. (Emphases added).
>
> *See also* Muthuswamy at column 4, lines 11-12 and 49-50.

That is, Muthuswamy uses rigid materials that are extremely non-flexible. The vitreous aluminum matrix or other reticulated material taught by

Muthuswamy would be expected to break or shatter if flexed. Muthuswamy thus also teaches away from the flexible fuel cell of the invention.

That is, Muthuswamy must use a reticulated vitreous metal. Muthuswamy aims at providing "a fuel cell that operates at pressure significantly higher than prior art cells (Muthuswamy at column 5, lines 21 and 22)." For this purpose, Muthuswamy necessarily adopts a coaxial fuel cell mechanically supported by a very rigid material, a reticulated vitreous metal such as an aluminum matrix either at the interior or at the exterior (Muthuswamy at column 3, lines from 8 to 24).

In contrast, the physically flexible fuel cell of the present invention does not employ such a hard matrix. A hard inflexible matrix is not required in the present invention.

As understood from Table A (below), illustrating the fuel cell structures of the invention and of Muthuswamy, the claimed fuel cell of the present invention is distinctly different from that of Muthuswamy.

Table A

	Present invention Claim 1	Present invention Claim 13	Muthuswamy Fig.2	Muthuswamy Fig.3
Interior	**Nothing**	**Nothing**	**RVM** (22)**	Chamber (38)
Inner electrode	Carbon particles* or catalyst	Catalyst	fibers (23)	fibers (37)
			Catalytic layer (24)	**Catalytic layer** (34)
Electrolyte	PEM	PEM	ITEM (25)	PEM (35)
Outer electrode	Carbon particles* or catalyst	Catalyst	**Catalytic layer** (26)	**Catalytic layer** (36)
			fibers (27)	fibers (33)
Exterior	**Nothing**	**Nothing**	Chamber(28)	**RVM** (32)**

* Carbon particles with catalyst loaded
** Reticulated Vitreous Metal
( ) Number in figure

As shown in Table A above, the catalyst in the fuel cell of the present invention is dispersed but is not covered with other layers, whereas Muthuswamy provides a catalytic layer between the fiber electrode and PEM.

Thus, the claimed fuel cell of the present invention has a particularly effective structure to readily pass methanol, thereby promoting contact of methanol with the catalyst and the membrane so closely as to promote a catalytic reaction of methanol with oxygen.

Regarding the size of the fuel cell, Muthuswamy fails to disclose any dimensional information of their fuel cell. Accordingly, a person skilled in the art would believe that Muthuswamy's fuel cell has conventional sizes (i.e., unable to miniaturize).

As a result, neither Bass nor Muthuswamy teach or suggest the miniaturization and physical flexibility on the fuel cell of the present invention.

Further, Bass and Muthuswamy's fuel cells will not operate when the solid cylindrical matrix is removed, as is demonstrated in failed examples in Bass. In contrast, the present invention produces a physically flexible and miniaturized methanol fuel cell being capable of supplying high output power density.

Therefore, a person having ordinary skill in the art would not be motivated by the teachings of Bass and Muthuswamy to produce the invention of claims 1 and 13. A *prima facie* case of obviousness has thus not been made. Claims depending upon claims 1 and 13 are patentable for at least the above reasons.

Further, even if one assumes *arguendo* that a *prima facie* case of obviousness could be made, this obviousness would be fully rebutted by unexpected results. These unexpected results include the low temperature operation discussed at page 12 of the specification (and claimed in claims 22 and 23). In contrast, Bass at Table 1 (column 9) has operating temperatures at about 200°C. Also, the invention shows superior current-potential characteristics and current-power characteristics, as are set forth in Figures 3(a), 3(b), 4(a) and (4b). The advantages of the invention are thus clear.

This rejection is overcome and withdrawal thereof is respectfully requested.

Information Disclosure Statement

The Examiner is respectfully requested to consider the Information Disclosure Statement filed March 17, 2005 and to make the initialed PTO-1449 form of record in the application in the next official action.

The Drawings

The Examiner has indicated that the drawing figures are acceptable in the Office Action mailed July 16, 2004.

Foreign Priority

The Examiner has acknowledged foreign priority, most recently in the Office Action mailed February 8, 2005.

Conclusion

Thus, with the above remarks and amendments, Applicants believe that the claims, as they now stand, define patentable subject matter such that passage of the instant invention to allowance is warranted. A Notice to that effect is earnestly solicited.

If any questions remain regarding the above matters, please contact Applicant's representative, Robert E. Goozner, Ph.D. (Reg. No. 42,593), in the Washington metropolitan area at the phone number listed below.

Pursuant to 37 C.F.R. §§ 1.17 and 1.136(a), Applicant(s) respectfully petition(s) for a one (1) month extension of time for filing a reply in connection with the present application, and the required fee of $120.00 is attached hereto.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

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